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Bern Network Epilepsy Sleep Consciousness

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Seminar, December 2, 2016

tDCS-methodology, application and available results

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Content

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- Methodology
- Application
- Results
  - Basic
  - Clinical
  - Sleep

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Methodology: the (DC-)stimulator

- 1 anode, 1 cathode (standard)
- Triggering possible
- Placebo-controlled
- Double-blind design possible
- tACS possible
- MR-compatible
- Current strength: < 2.0 mA (ECT: < 900 mA)

High-Definition-tDCS

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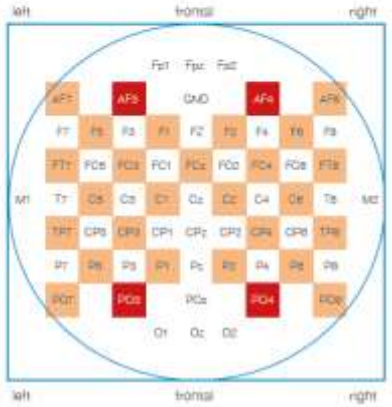
HD tDCS-EEG **wave**guard cap

- Up to 29 tDCS-Electrodes
- Only for research



tDCS Principle

- Modulation of spontaneous neuronal activity
- **Anodal** stimulation: increase of the membrane's resting potential → depolarisation

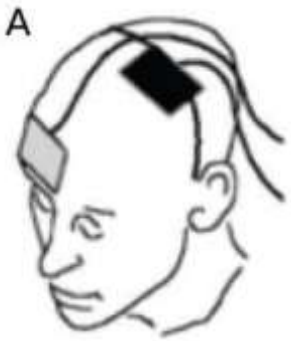
  Increase of the cortical excitability

- **Cathodal** stimulation: decrease of the membrane's resting potential → hyperpolarisation

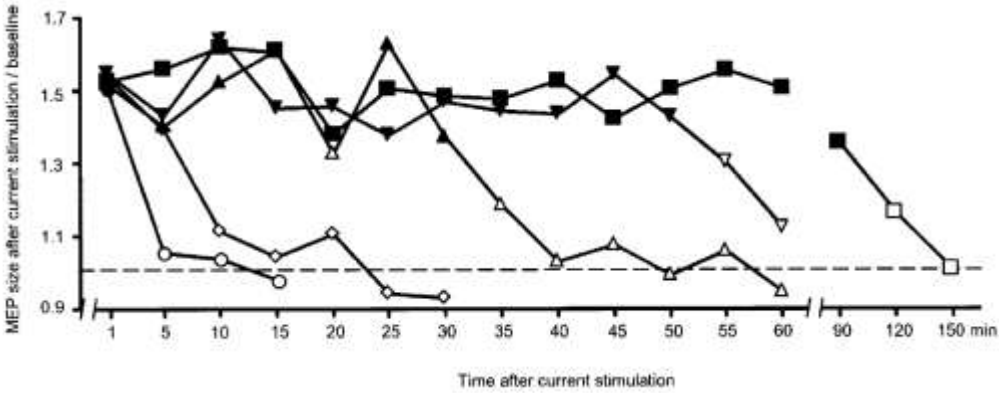
  Decrease of the cortical excitability

Poreisz et al. (2007) *Brain Res Bull*

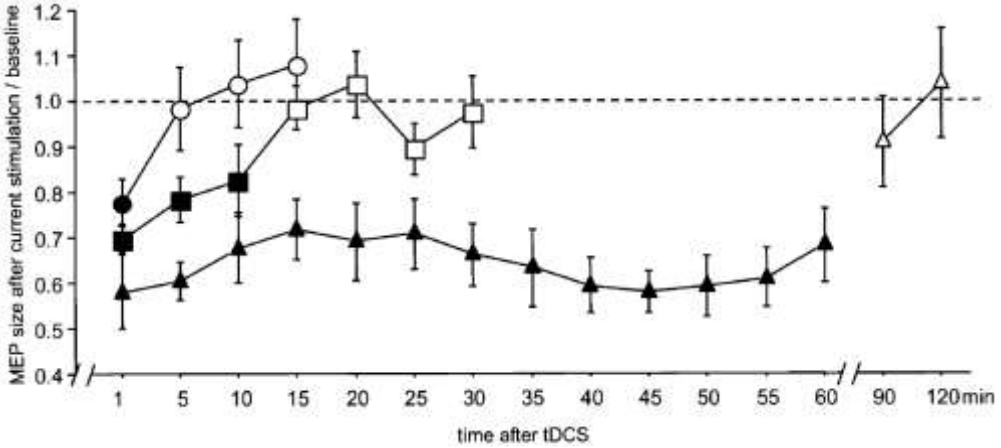
Anodal vs. Cathodal polarisation



Anodal stimulation



Cathodal stimulation



Nitsche & Paulus (2001) *Neurology* / Nitsche et al. (2003) *Clin Neurophysiol*

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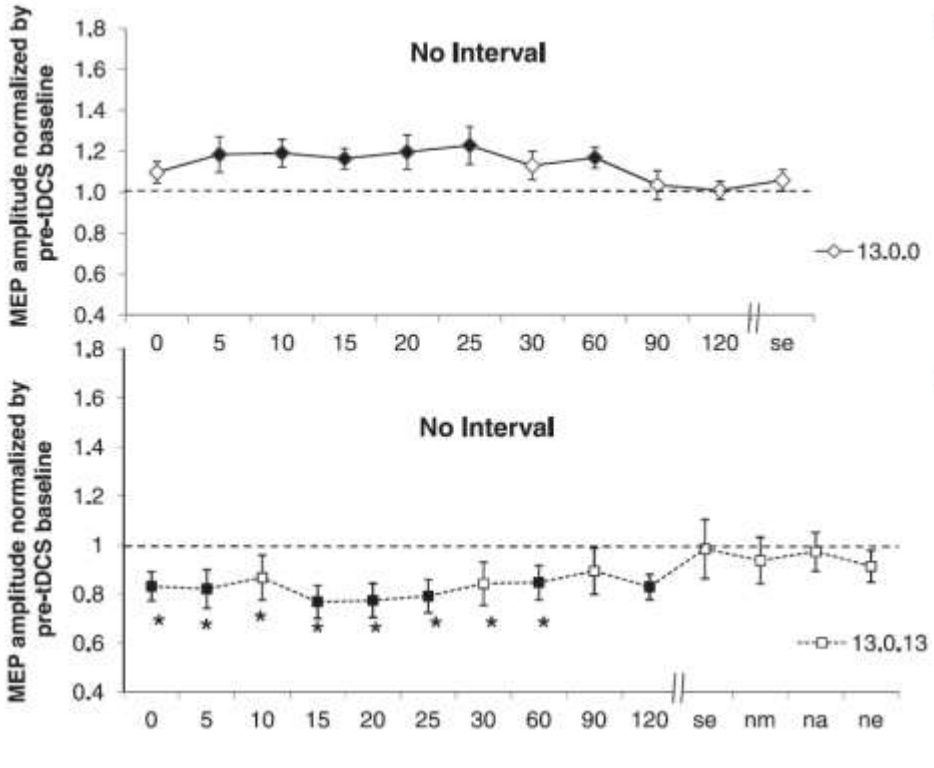
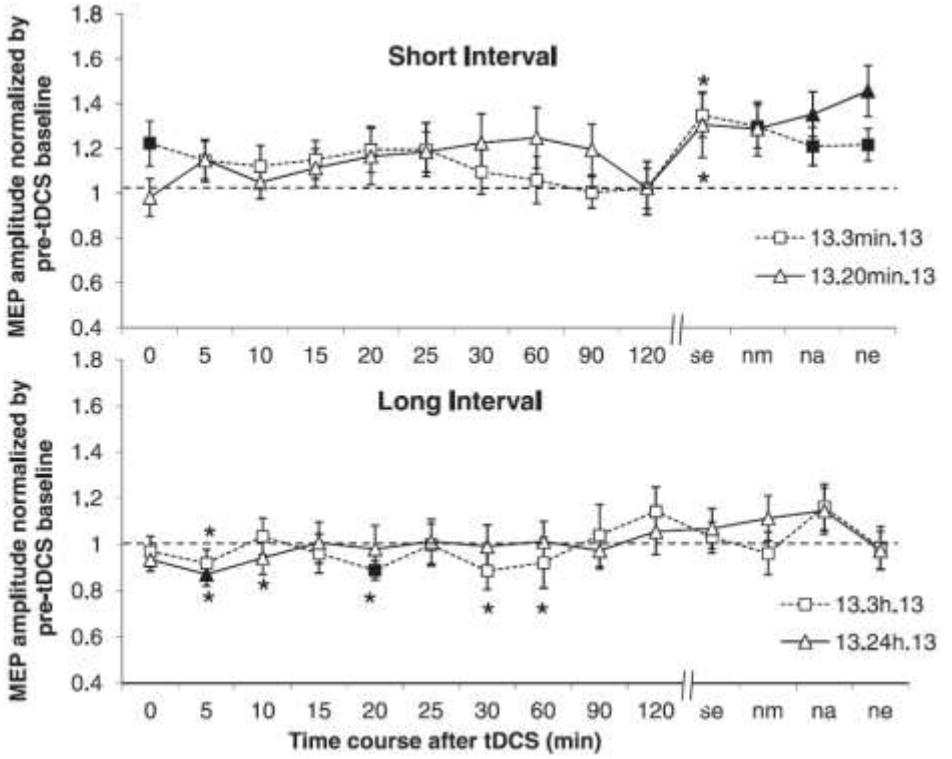
Aftereffects





Monte-Silva et al. (2013) *Brain Stim*

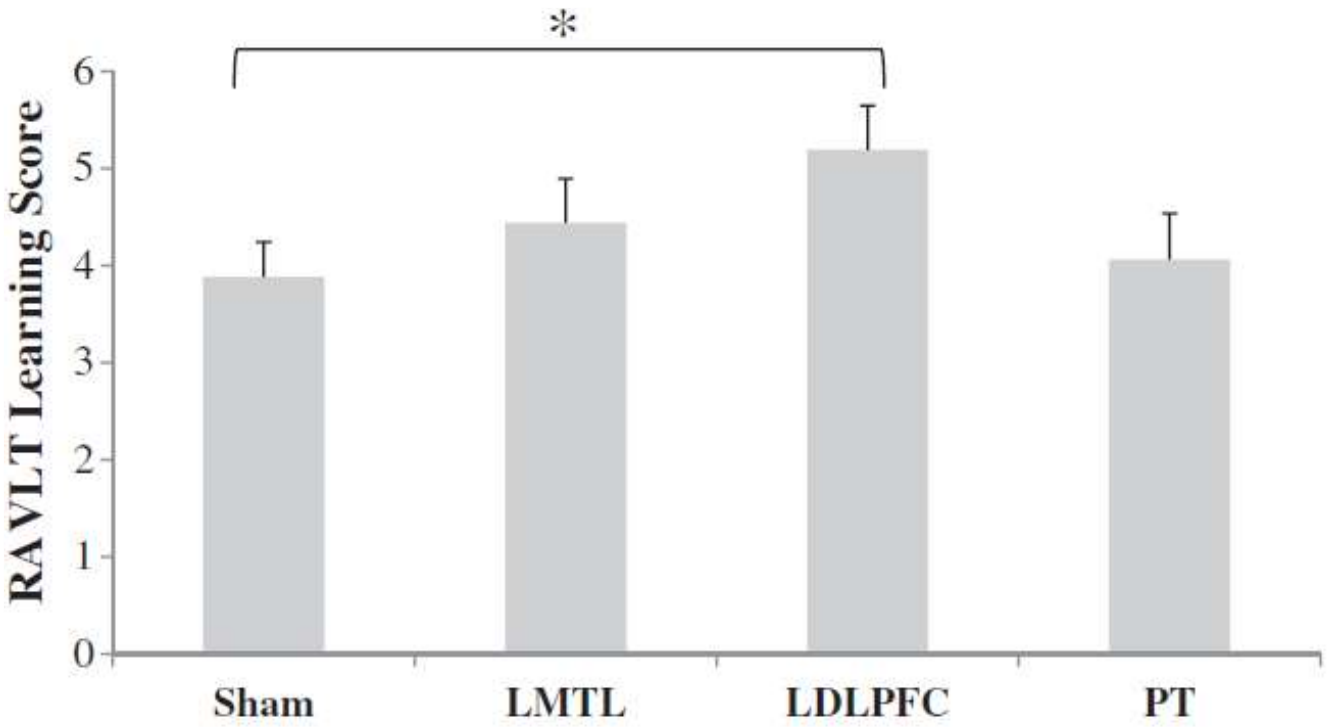
tDCS application

- Guidelines:
  - Nitsche, Liebetanz, et al. (2003) *Clin Neurophysiol*
  - Poreisz, Boros, Antal, & Paulus (2007) *Brain Res Bull*
  - Woods, Antal, Bikson, et al. (2016) *Clin Neurophysiol*

Requirements

- Hypothesis
- Electrode location
- Anodal/cathodal stimulation
- Stimulation protocol (duration, sequence)
- Electrode type
- Contact medium

Stimulation model simulation

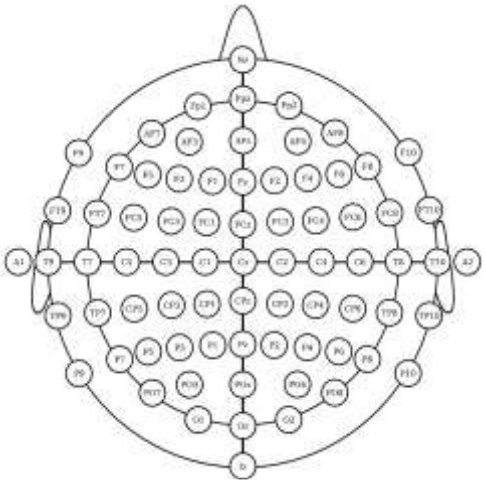


Nikolin et al. (2015) *NeuroImage*

Reproducibility

> Electrode placement / preparation

International 10-20 system



Neuro-navigation

Physiology-based (works only for motor or other primary cortices)

> Contact medium:
  - avoid oversaturation (NaCl-liquid)
  - control constant amount (e.g. syringes)

tDCS side-effects

- Occasional side-effects:
  - headache
  - vertigo
  - fatigue
  - nausea
  - tingling/burning sensation under the electrodes

Palm et al. (2008) *Brain Stim*

Brunoni et al. (2011) *Int J Neuropsychopharmacol*

Promising results

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The Journal of Neuroscience, November 3, 2004 • 24(44):9985–9992 • 9985

Behavioral/Systems/Cognitive

Transcranial Direct Current Stimulation during Sleep Improves Declarative Memory

Lisa Marshall, Matthias Mölle, Manfred Hallschmid, and Jan Born
Institute of Neuroendocrinology H23a, University of Lübeck, 23538 Lübeck, Germany

nature Vol 444|30 November 2006|doi:10.1038/nature05278

LETTERS

Boosting slow oscillations during sleep potentiates memory

Lisa Marshall[1], Halla Helgadóttir[1], Matthias Mölle[1] & Jan Born[1]

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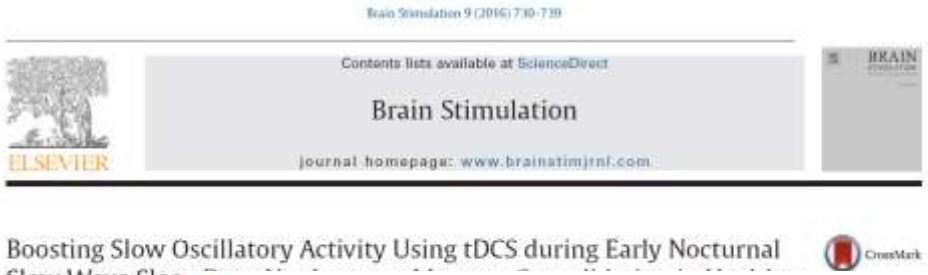
Disillusioning results



Brain Stimulation 9 (2016) 730–739

Contents lists available at ScienceDirect

Brain Stimulation

journal homepage: www.brainstimjrnl.com

Boosting Slow Oscillatory Activity Using tDCS during Early Nocturnal Slow Wave Slee
Older Adults

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[d] Center for Stroke Research, Charit
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frontiers in Aging Neuroscience

ORIGINAL RESEARCH
published: 14 December 2015
doi: 10.3389/fnagi.2015.00230

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No Significant Effect of Prefrontal tDCS on Working Memory Performance in Older Adults

Jonna Nilsson, Alexander V. Lebedev and Martin Lövdén*

Aging Research Center, Karolinska Institutet and Stockholm University, Stockholm, Sweden

controlled crossover study

Gregory L. Sahlem [a,*], Bashar W. Badran [a,d], Jonathan J. Halford [b], Nolan R. Williams [a,b], Jeffrey E. Korte [c], Kimberly Leslie [a], Martha Strachan [a], Jesse L. Breedlove [d], Jennifer Runion [a], David L. Bachman [b], Thomas W. Uhde [a], Jeffery J. Borckardt [a], Mark S. George [a,b,d,e]

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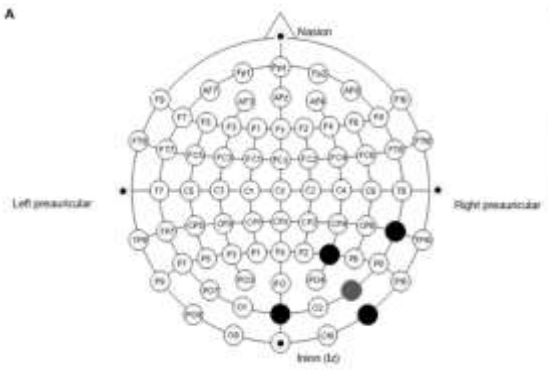
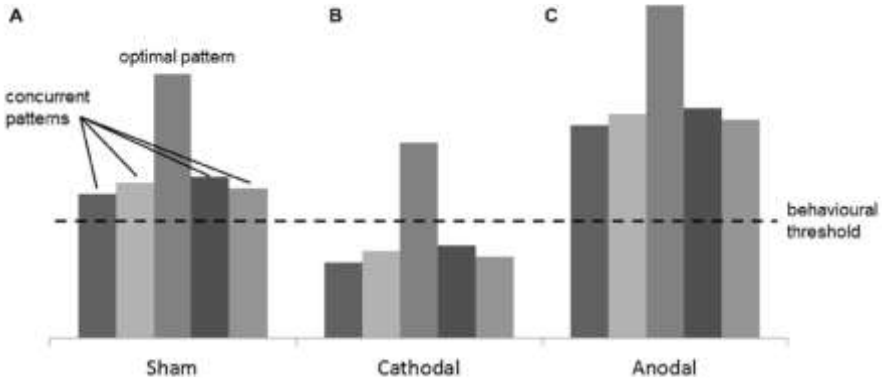
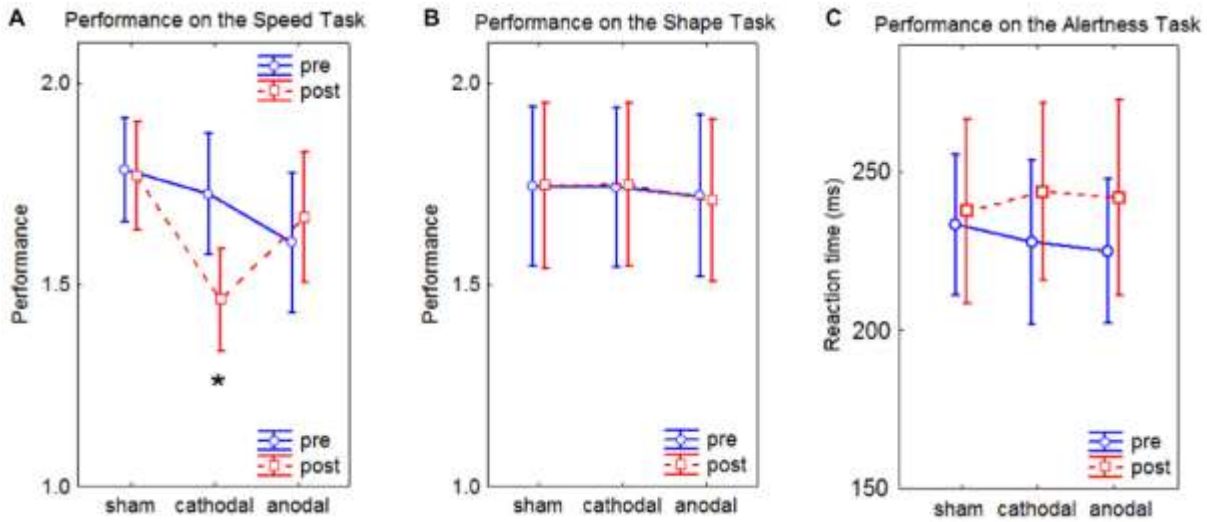
tDCS-induced inhibition as a boost for focused perception?

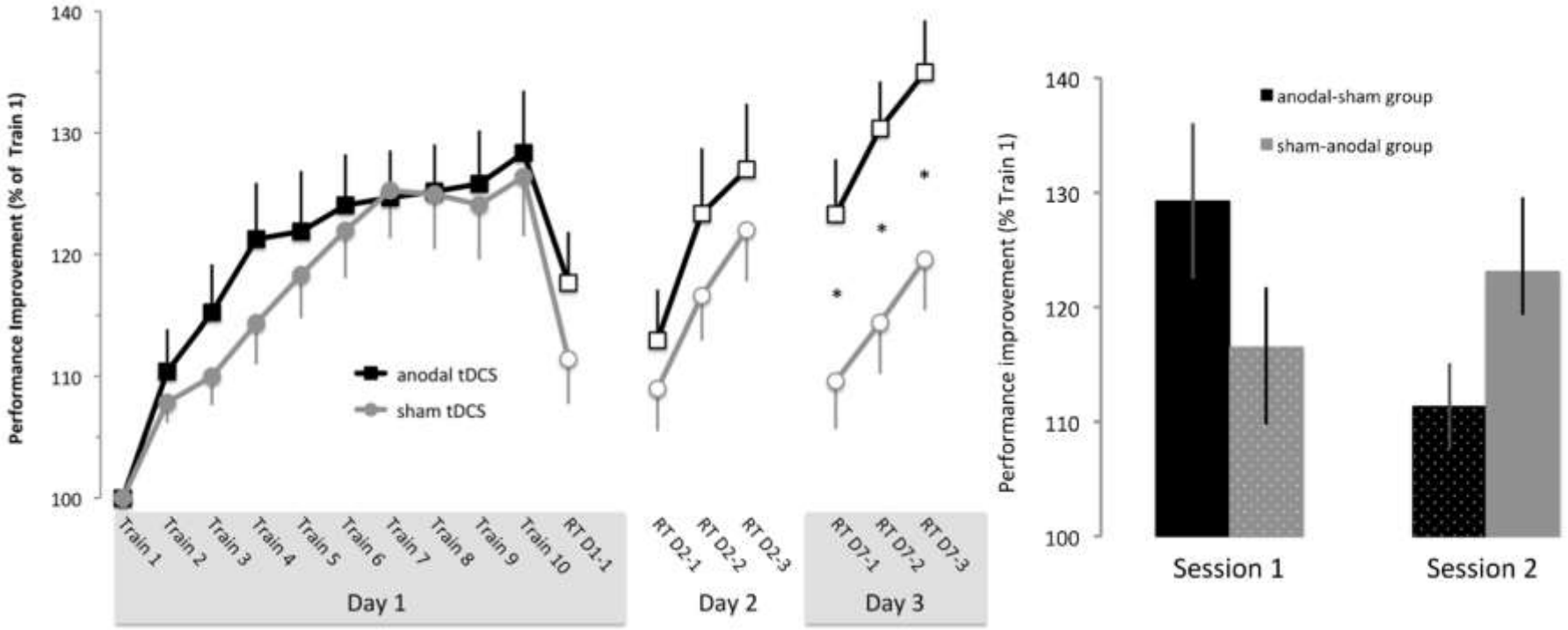






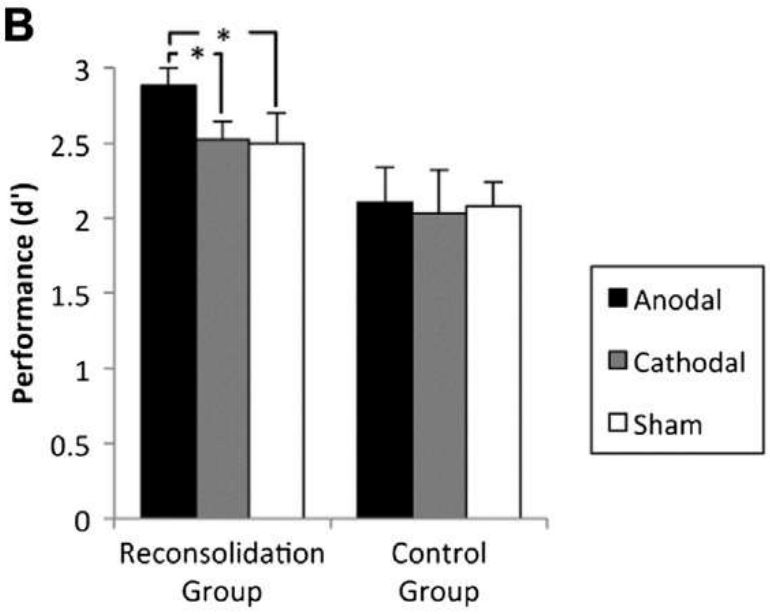
Zito et al. (2015) *Front Behav Neurosci*

tDCS-moderated plasticity



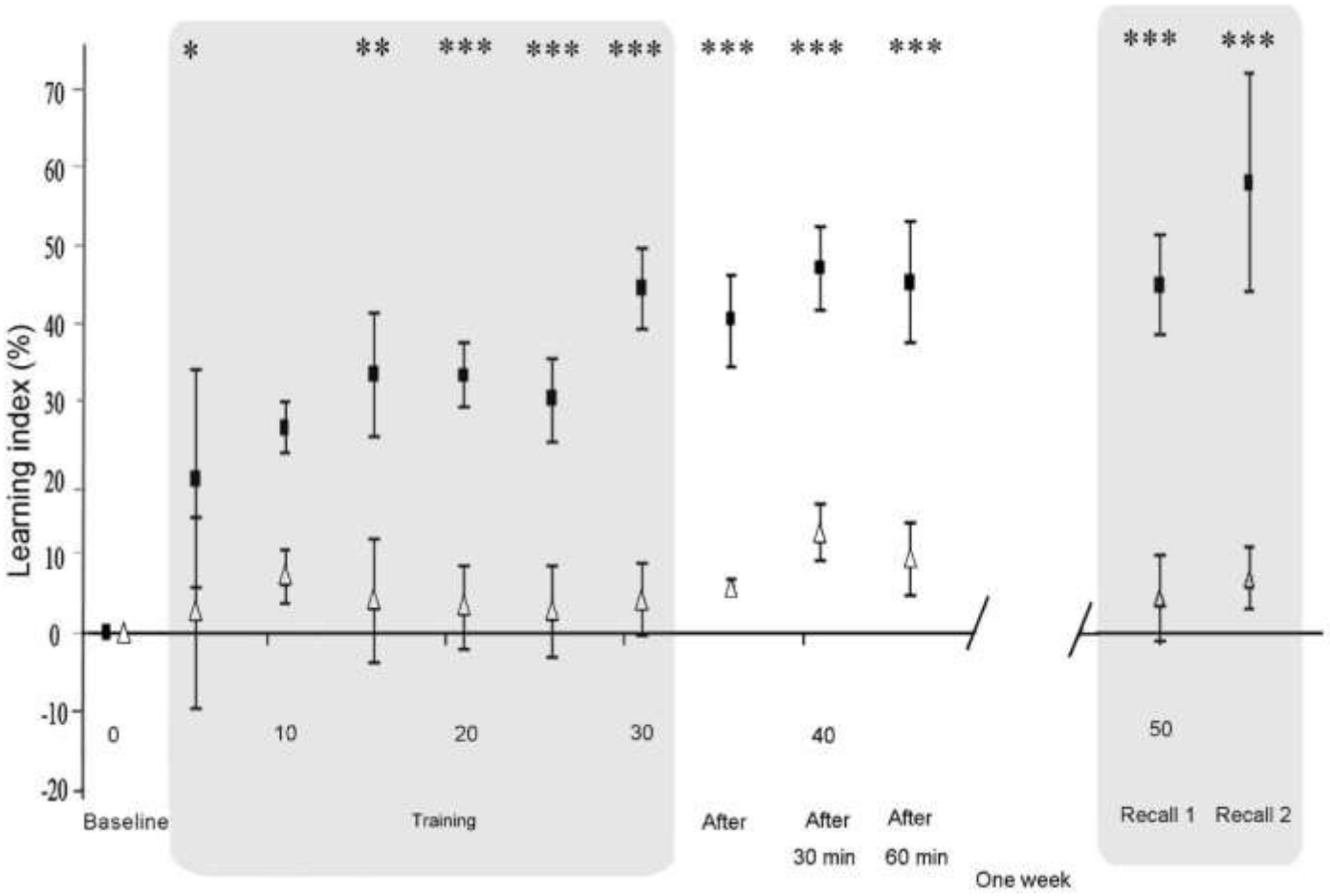
Rroji et al. (2015) *PLoSOne*

tDCS and memory consolidation



Javadi & Cheng (2013) *Brain Stim*

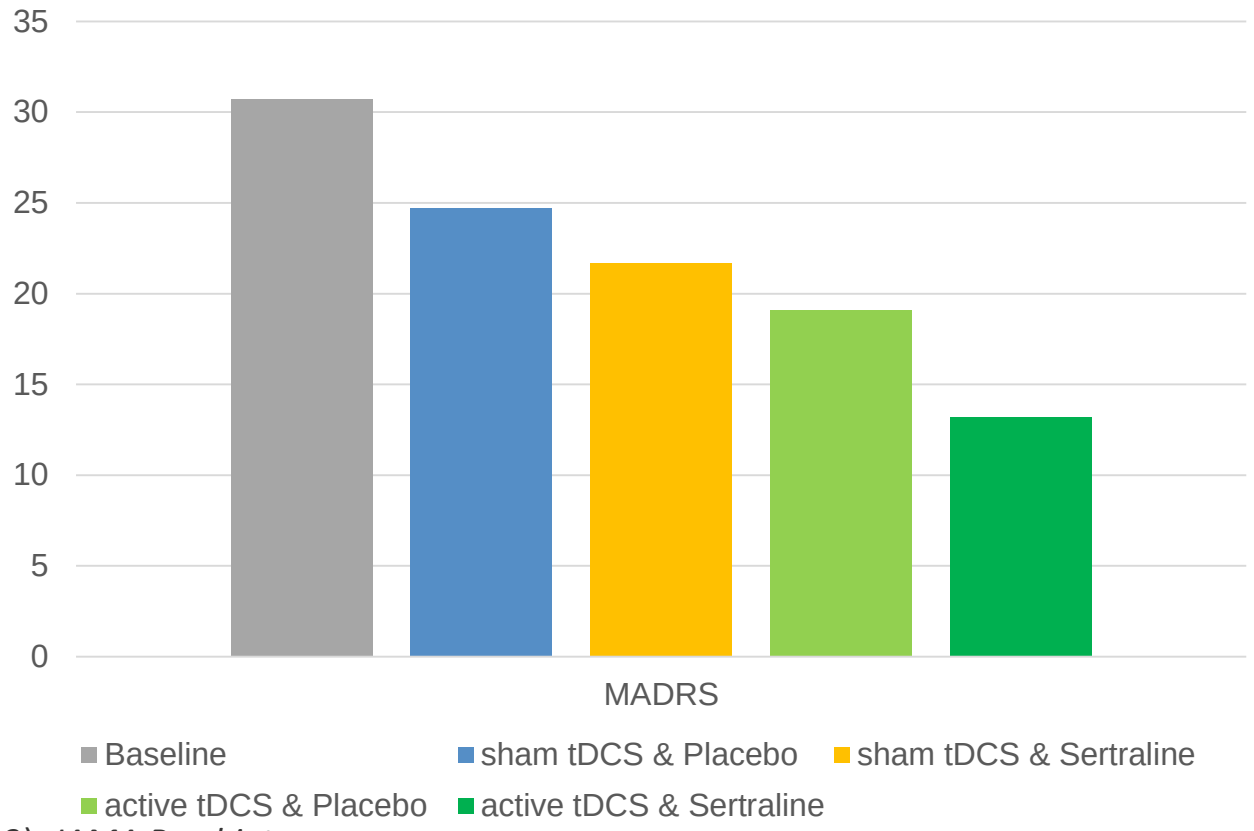
Enhancing motor skills in stroke patients



Lefebvre et al. (2012) *Front Hum Neurosci*

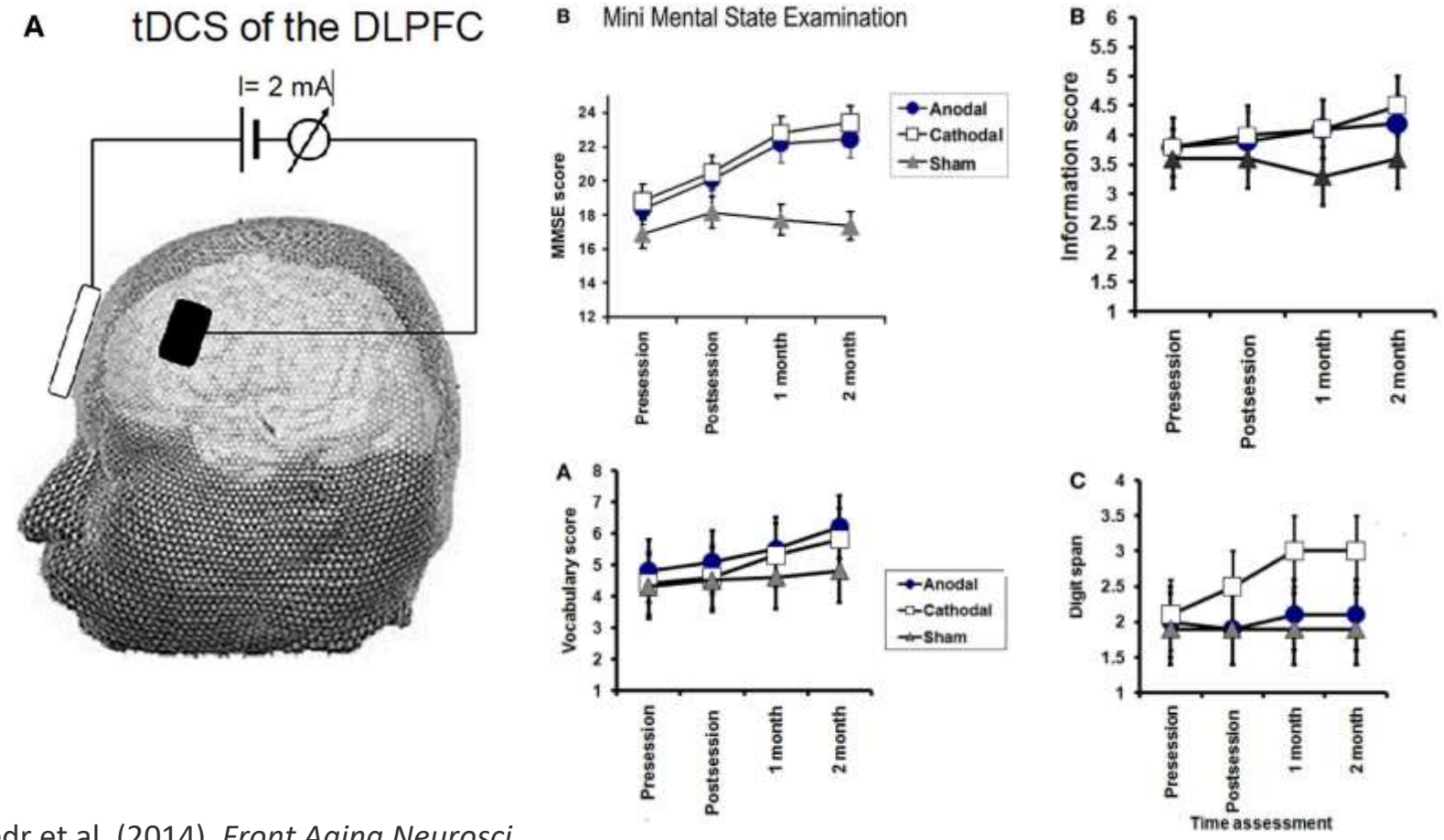
tDCS in depression

> Dependent variable: Montgomery-Asberg Depression Rating Scale (MADRS)



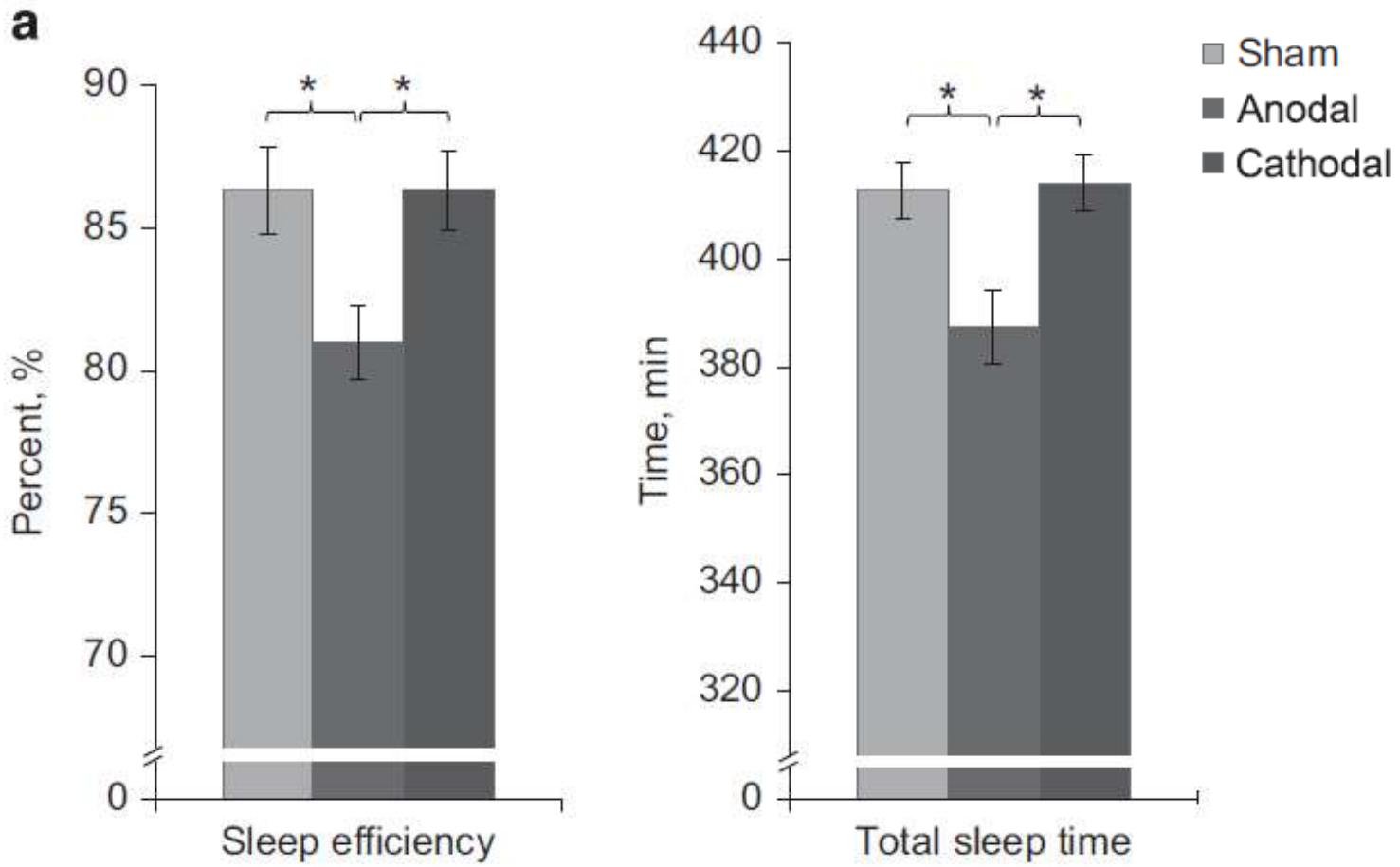
Brunoni et al. (2013) *JAMA Psychiatry*

tDCS and cognition in Alzheimer's disease



Khedr et al. (2014) *Front Aging Neurosci*

tDCS and sleep

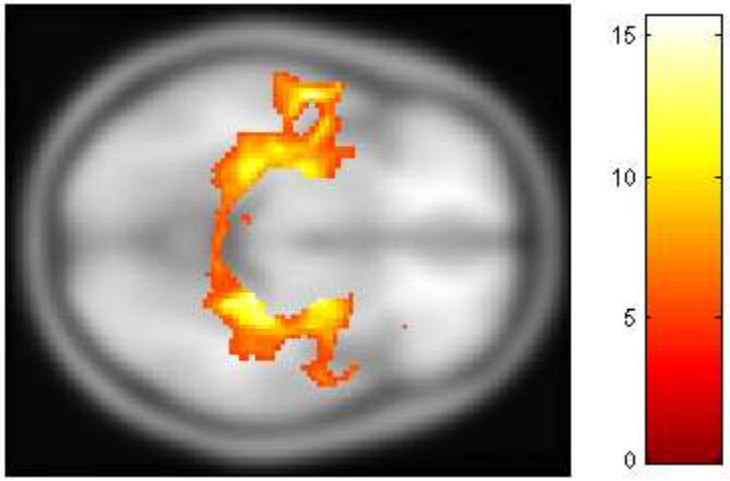


Frase et al. (2016) *Neuropsychopharmacol*

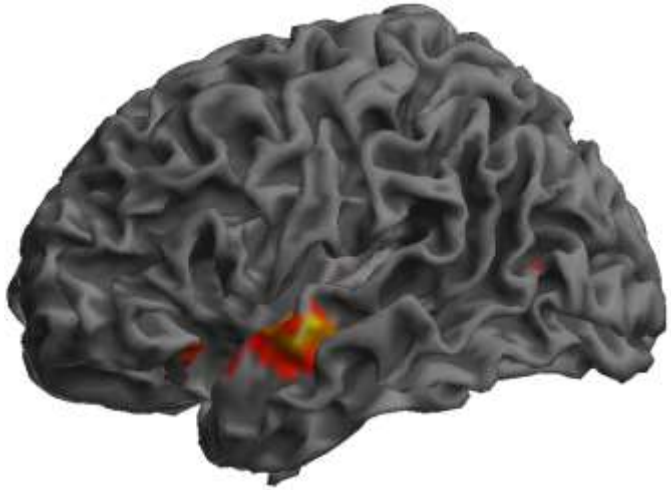
Own study

- Is it possible to enhance sleep-dependent memory consolidation?
- More refined tDCS protocol
- Target the slow waves (and sleep spindles) with tDCS
- Stimulation location based on functional connectivity data

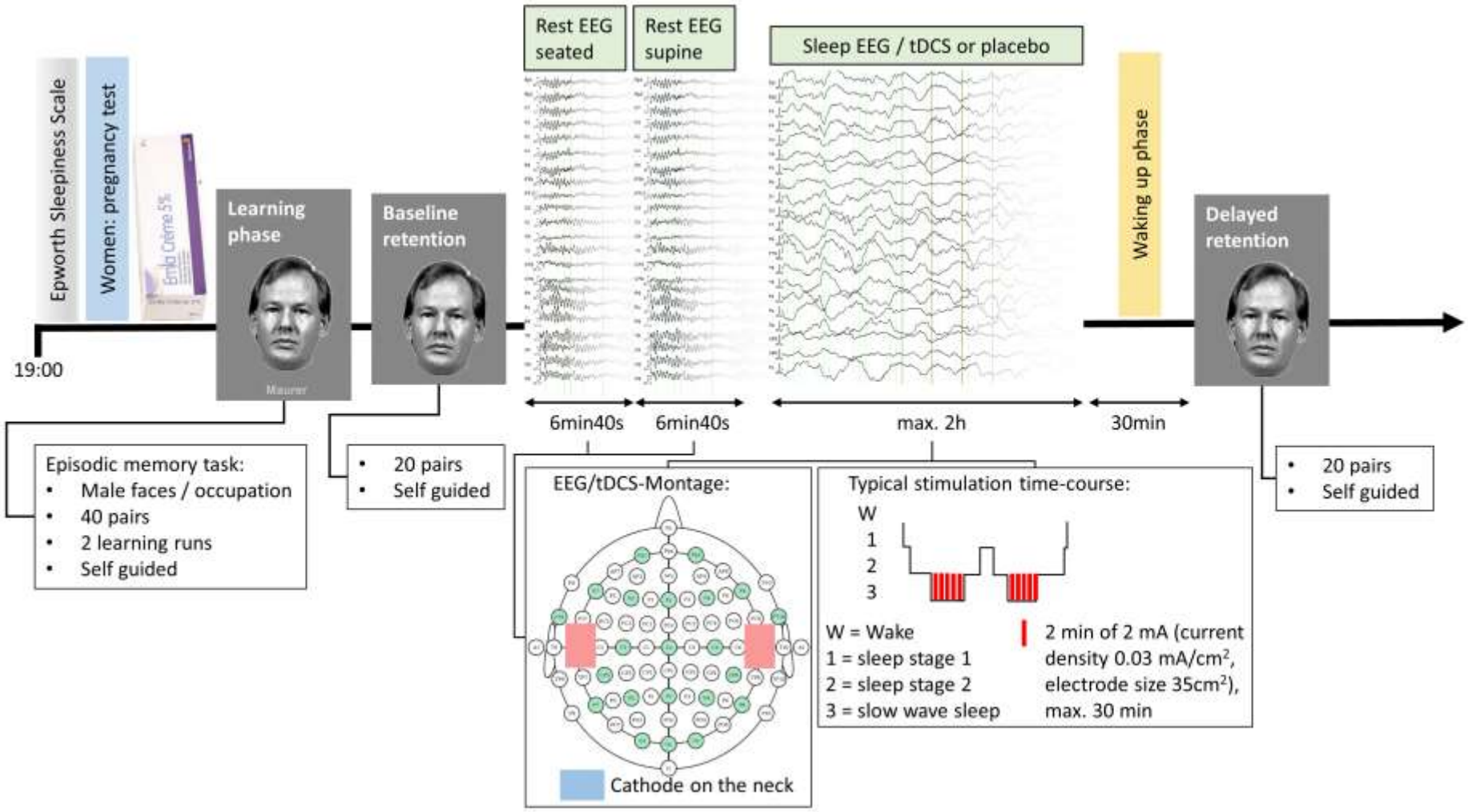
Functional connectivity of hippocampal area



$p < 0.0001$ (uncorr.)



Experimental procedure



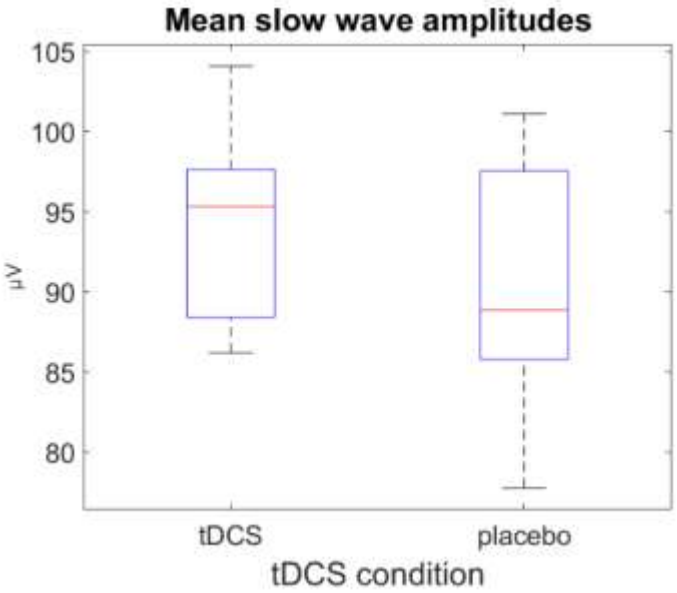
Bilateral temporal anodal tDCS increases slow wave amplitudes

Effect of tDCS during S3 on memory consolidation:

Partial Correlation of tDCS-dependent memory performance and real slow wave stimulation:
tDCS: $r = 0.89$, $p < 0.01$
Sham: $r = -0.22$, $p = 0.56$

→ The more slow waves are stimulated, the better the memory consolidation

Effect of tDCS on slow wave amplitude:



Mean = 93.8 (*SD* = 5.7) *Mean* = 90.4 (*SD* = 6.9)

$T = 2.2$, $p < 0.05$

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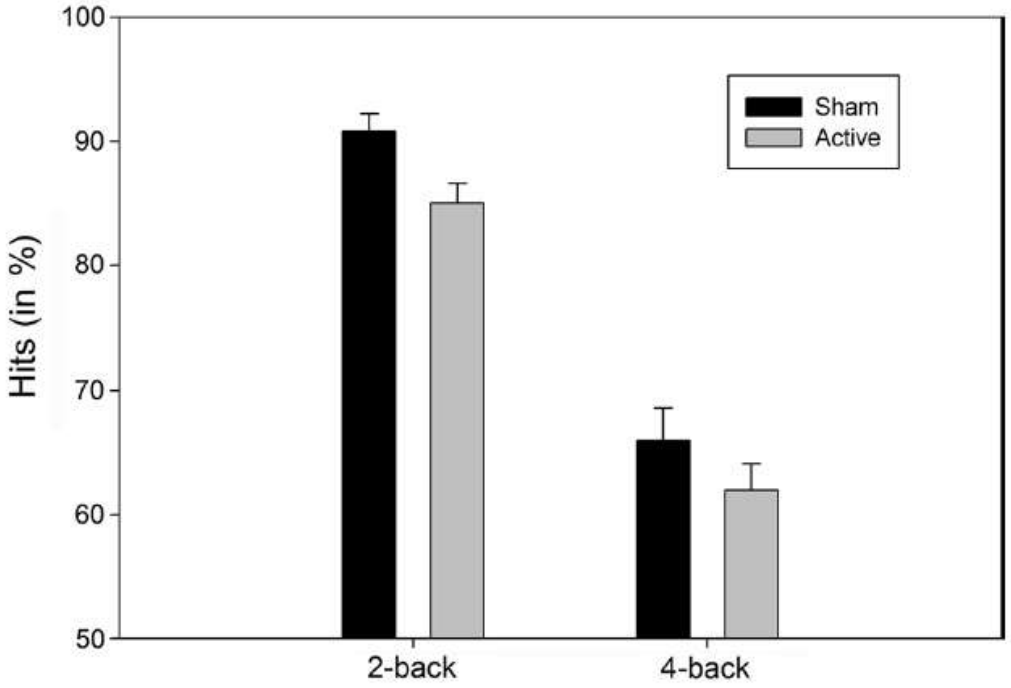

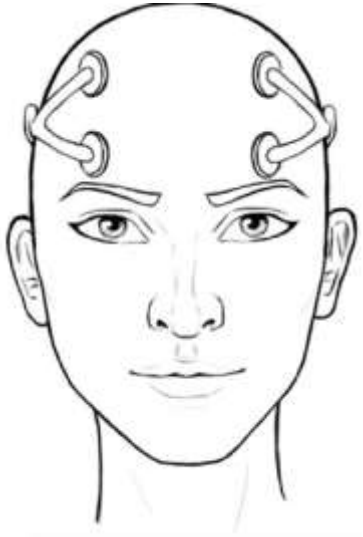

Steenbergen et al. (2016) *Exp Brain Res*

Acknowledgment / Literature

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- Thomas Dierks
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- Simon Ruch

Amadi, U., et al. (2013). "Polarity-specific effects of motor transcranial direct current stimulation on fMRI resting state networks." Neuroimage.

Barbieri, M., et al. (2016). "Anodal-tDCS over the human right occipital cortex enhances the perception and memory of both faces and objects." Neuropsychologia 81: 238-244.

Brunoni, A. R., et al. (2013). "The sertraline vs. electrical current therapy for treating depression clinical study: results from a factorial, randomized, controlled trial." JAMA Psychiatry 70(4): 383-391.

Brunoni, A. R., et al. (2011). "A systematic review on reporting and assessment of adverse effects associated with transcranial direct current stimulation." Int J Neuropsychopharmacol 14(8): 1133-1145.

Frase, L., et al. (2016). "Modulation of Total Sleep Time by Transcranial Direct Current Stimulation (tDCS)." Neuropsychopharmacology 41(10): 2577-2586.

Fritsch, B., et al. (2010). "Direct current stimulation promotes BDNF-dependent synaptic plasticity: potential implications for motor learning." Neuron 66(2): 198-204.

Javadi, A. H. and P. Cheng (2013). "Transcranial direct current stimulation (tDCS) enhances reconsolidation of long-term memory." Brain Stimul 6(4): 668-674.

Jog, M. V., et al. (2016). "In-vivo Imaging of Magnetic Fields Induced by Transcranial Direct Current Stimulation (tDCS) in Human Brain using MRI." Sci Rep 6: 34385.

Khedr, E. M., et al. (2014). "A double-blind randomized clinical trial on the efficacy of cortical direct current stimulation for the treatment of Alzheimer's disease." Front Aging Neurosci 6: 275.

Lefebvre, S., et al. (2012). "Dual-tDCS Enhances Online Motor Skill Learning and Long-Term Retention in Chronic Stroke Patients." Frontiers in Human Neuroscience 6: 343.

Marshall, L., et al. (2006). "Boosting slow oscillations during sleep potentiates memory." Nature 444(7119): 610-613.

Marshall, L., et al. (2004). "Transcranial direct current stimulation during sleep improves declarative memory." J Neurosci 24(44): 9985-9992.

Monte-Silva, K., et al. (2013). "Induction of late LTP-like plasticity in the human motor cortex by repeated non-invasive brain stimulation." Brain Stimul 6(3): 424-432.

Nikolin, S., et al. (2015). "Focalised stimulation using high definition transcranial direct current stimulation (HD-tDCS) to investigate declarative verbal learning and memory functioning." Neuroimage 117: 11-19.

Nilsson, J., et al. (2015). "No Significant Effect of Prefrontal tDCS on Working Memory Performance in Older Adults." Front Aging Neurosci 7: 230.

Nitsche, M. A., et al. (2003). "Level of action of cathodal DC polarisation induced inhibition of the human motor cortex." Clin Neurophysiol 114(4): 600-604.

Nitsche, M. A. and W. Paulus (2001). "Sustained excitability elevations induced by transcranial DC motor cortex stimulation in humans." Neurology 57(10): 1899-1901.

Passmann, S., et al. (2016). "Boosting Slow Oscillatory Activity Using tDCS during Early Nocturnal Slow Wave Sleep Does Not Improve Memory Consolidation in Healthy Older Adults." Brain Stimul 9(5): 730-739.

Poreisz, C., et al. (2007). "Safety aspects of transcranial direct current stimulation concerning healthy subjects and patients." Brain Res Bull 72(4-6): 208-214.

Rroji, O., et al. (2015). "Anodal tDCS over the Primary Motor Cortex Facilitates Long-Term Memory Formation Reflecting Use-Dependent Plasticity." PLoS One 10(5): e0127270.

Sahlem, G. L., et al. (2015). "Oscillating Square Wave Transcranial Direct Current Stimulation (tDCS) Delivered During Slow Wave Sleep Does Not Improve Declarative Memory More Than Sham: A Randomized Sham Controlled Crossover Study." Brain Stimul 8(3): 528-534.

Steenbergen, L., et al. (2016). ""Unfocus" on foc.us: commercial tDCS headset impairs working memory." Exp Brain Res 234(3): 637-643.

Zito, G. A., et al. (2015). "Cathodal HD-tDCS on the right V5 improves motion perception in humans." Front Behav Neurosci 9: 257.